International Conference on Frontiers of Polymers and Advanced Materials
(11th: 20-25 May 2011: Univ. of Pretoria, South Africa)

1. The effect of specimen geometry and testing parameters on impact properties of injection moulded glass fiber/polyamide 6 composites, by Aziz Hassan, Asfarina A. Hassan, M.I. Mohd. Rafiq, Rosiyah Yahya and Amran Hussin.

2. Fibre length, thermal and mechanical properties of injection-moulded glass-fibre/polyamide 6,6 composite: effect of moisture absorption, by Rosiyah Yahya, Noordini M.Salleh, Normasmira A. Rahman and Aziz Hassan.

11TH INTERNATIONAL CONFERENCE ON

FRONTIERS OF POLYMERS AND ADVANCED MATERIALS

(11TH ICFPAM)

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OF MALAYA
KUALA LUMPUR

THE EFFECT OF SPECIMEN GEOMETRY AND TESTING PARAMETERS ON IMPACT PROPERTIES OF INJECTION MOULDED GLASS FIBRE/POLYAMIDE 6 COMPOSITES

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Introduction

- **Composites –** two or more distinct components are combined together
- **Polyamide 6**
  Melting point : 222˚C
  Density : 1.14 g/cm^3
- **E-glass –** reinforcing agent
  Diameter : 10 µm
  Density : 2.55 g/cm^3

Issues

- Differences in values (W, P, G_c, K_c) is a major issue in impact property data

- Understanding the factors affecting impact properties

Objective

To investigate the influence of:-

- specimen geometry - B, D, S
- impactor load weight - m
- impactor velocity - v

on impact properties of glass fibre reinforced polyamide 6 composite.

Experimental

Specimen preparation

Technyl® C216
+
Technyl® C216 V30 NAT

→

Injection moulded
(Boy® 55M)

→

Impact test bars
(two sizes)

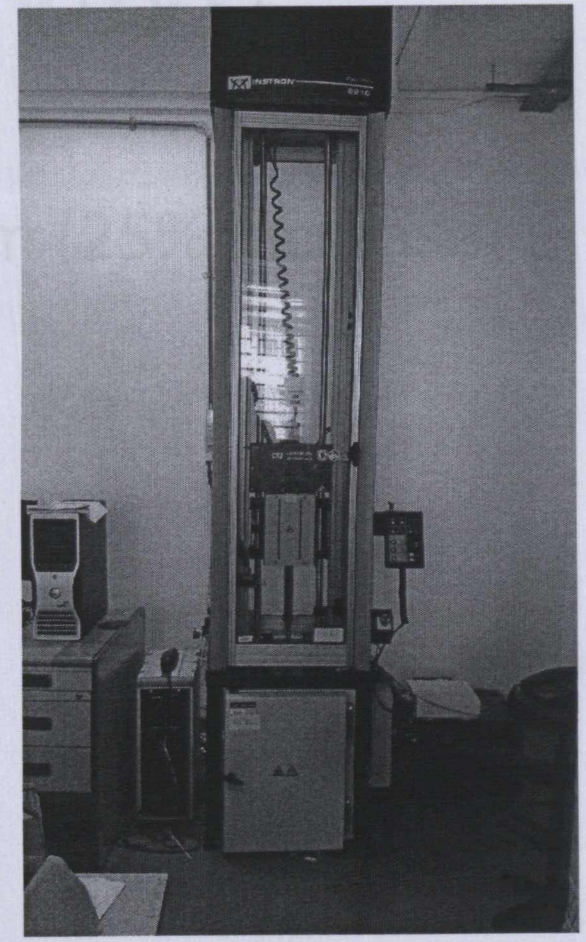
↓

Notching
(a/D = 0.1 - 0.4),
Testing

Impact properties determination

Impact testing

- Instron Dynatup 9210 Falling Weight Impact Tester
- Charpy mode
- V shaped tup
- 25°C



Effect of Specimen Geometry (B x D x S)

– Small: 6 mm x 12 mm x 48 mm

– Large: 7.5 mm x 15 mm x 60 mm (25% increase)

Fixed parameters

– Velocity: 1.55 m s^{-1}

– Load weight: 7.65 kg

Effect of Impactor Velocity

– Velocity: 0.83, 1.22, 1.55 and 1.96 m s^{-1}

Fixed parameters

– Load weight: 7.65 kg

– Specimen: Large

Effect of Impactor Load Weight

– Load weight: 6.45, 7.65 and 10.05 kg

Fixed parameters

– Velocity: 1.22 m s^{-1}

– Specimen: Large

Results and Discussion

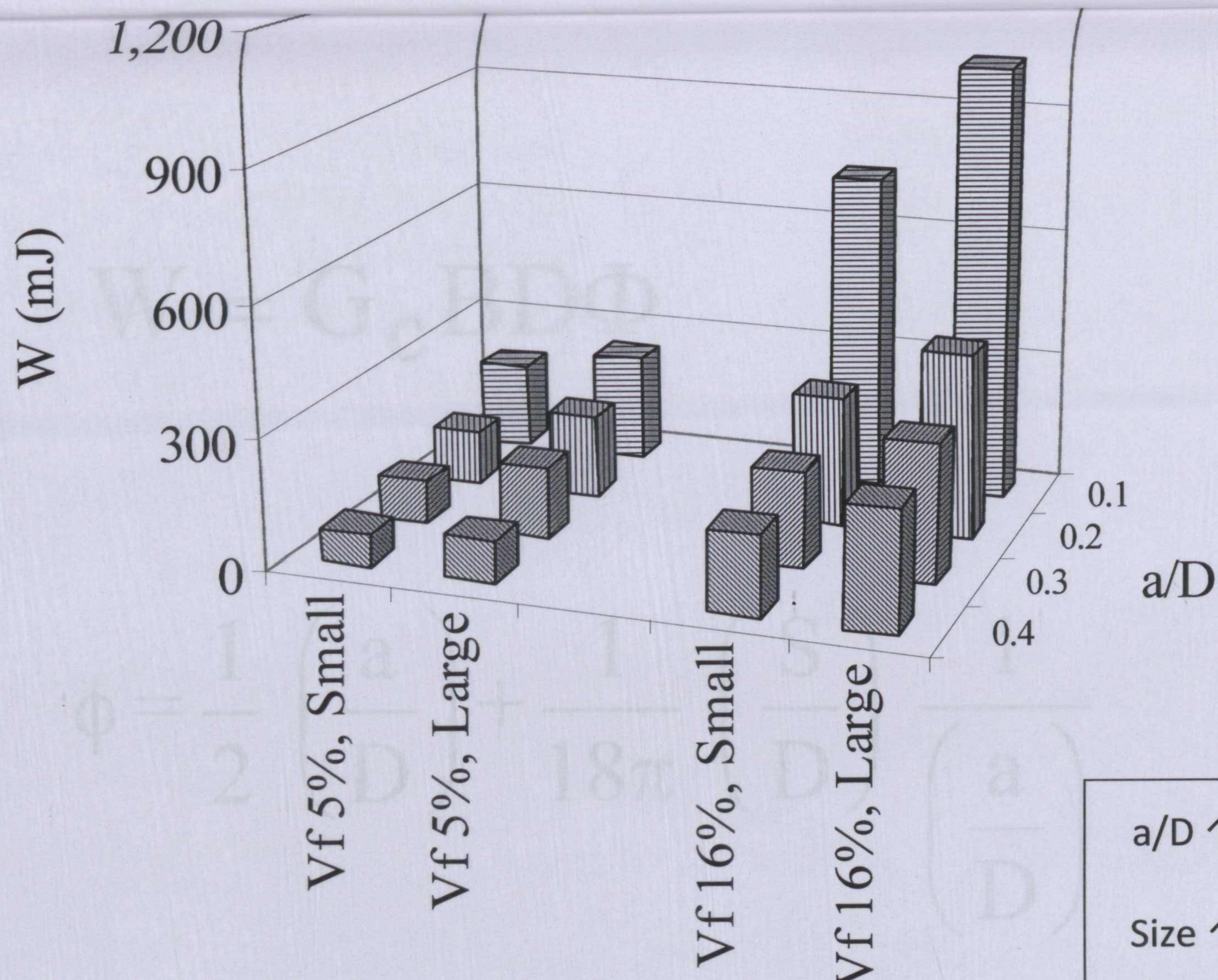
W – Fracture energy

P – Peak load

G_c – Critical strain energy release rate

K_c – Critical stress intensity factor

Effect of Specimen Geometry



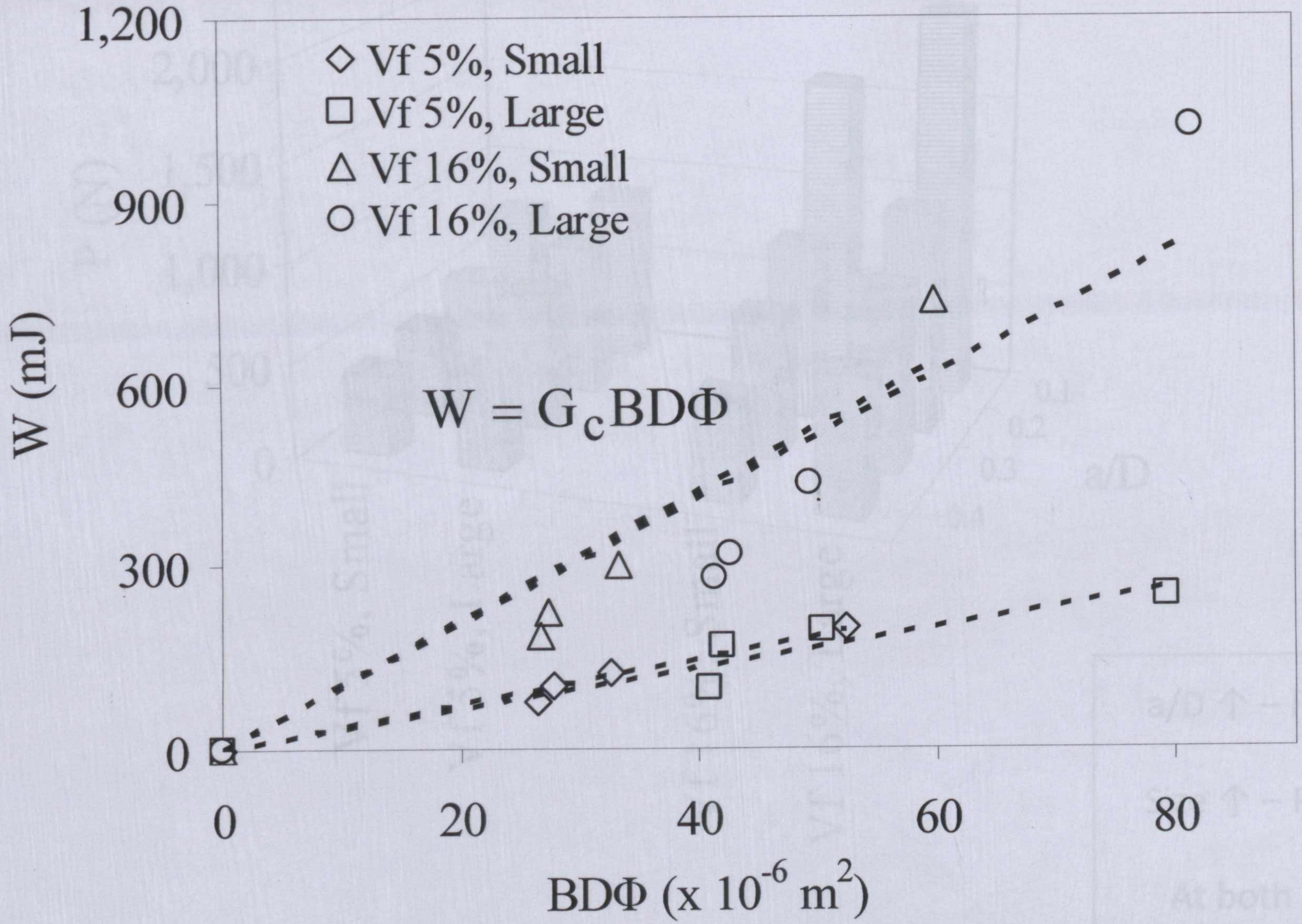
a/D ↑ – W ↓

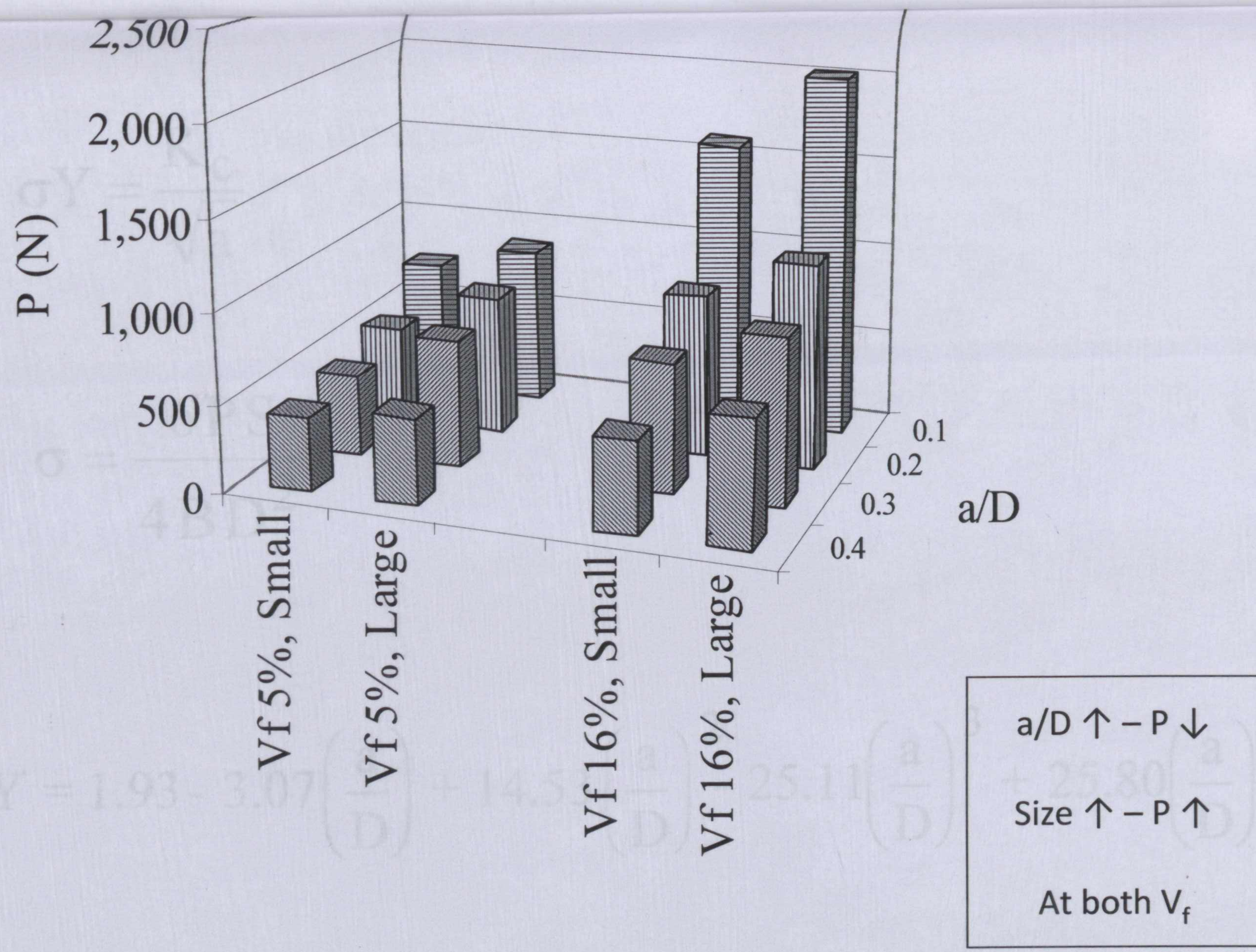
Size ↑ – W ↑

At both V_f

$$W = G_c BD\Phi$$

$$\phi = \frac{1}{2}\left(\frac{a}{D}\right) + \frac{1}{18\pi}\left(\frac{S}{D}\right)\frac{1}{\left(\frac{a}{D}\right)}$$


1,200
900
600
300
0
W (mJ)
◇ Vf 5%, Small
□ Vf 5%, Large
△ Vf 16%, Small
○ Vf 16%, Large
$W = G_c BD\Phi$
0
20
40
60
80
$BD\Phi$ (x 10^{-6} m^2)

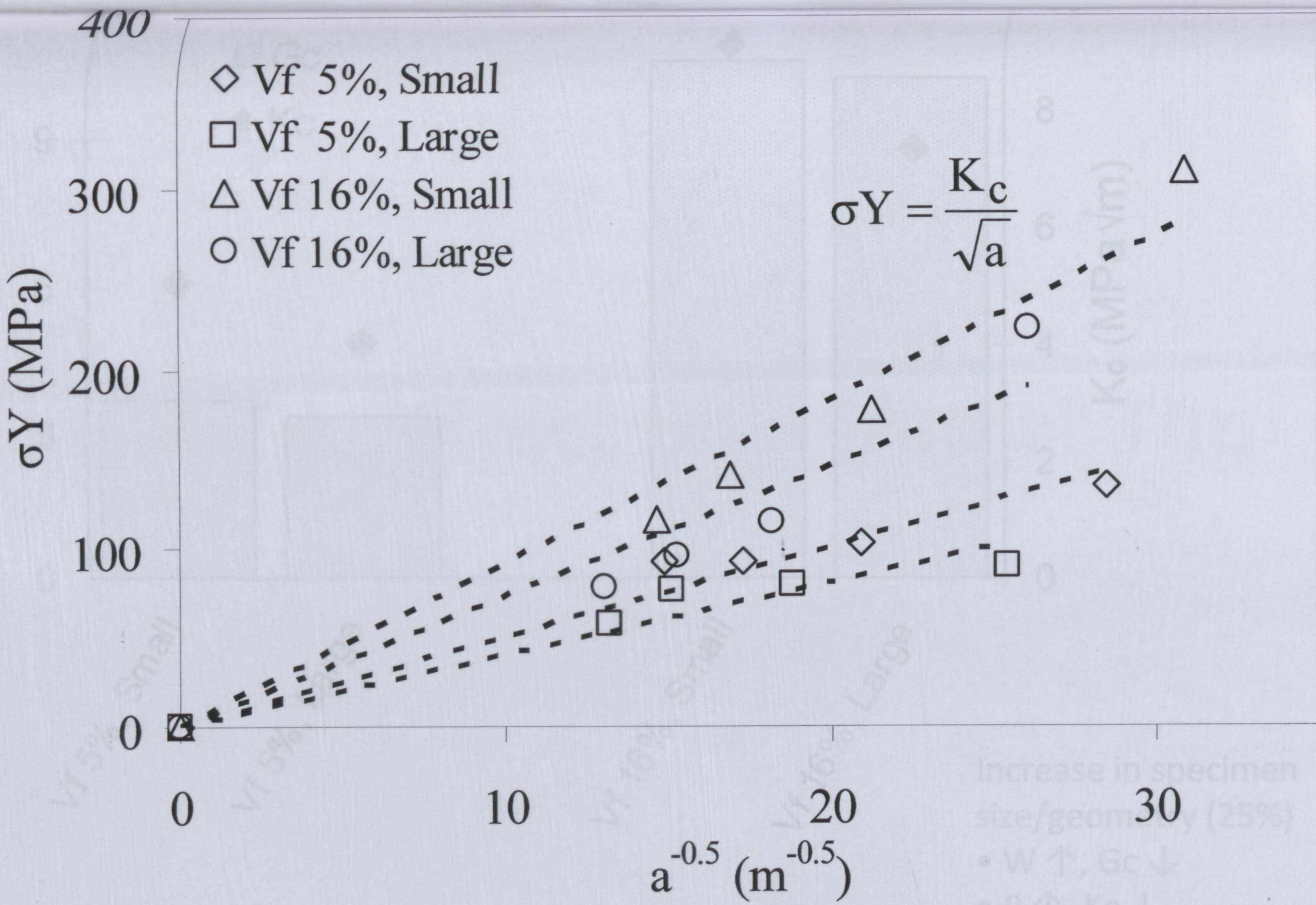


P (N)
2,500
2,000
1,500
1,000
500
0
Vf 5%, Small
Vf 5%, Large
Vf 16%, Small
Vf 16%, Large
0.1
0.2
0.3
0.4
a/D
a/D ↑ – P ↓
Size ↑ – P ↑
At both V_f

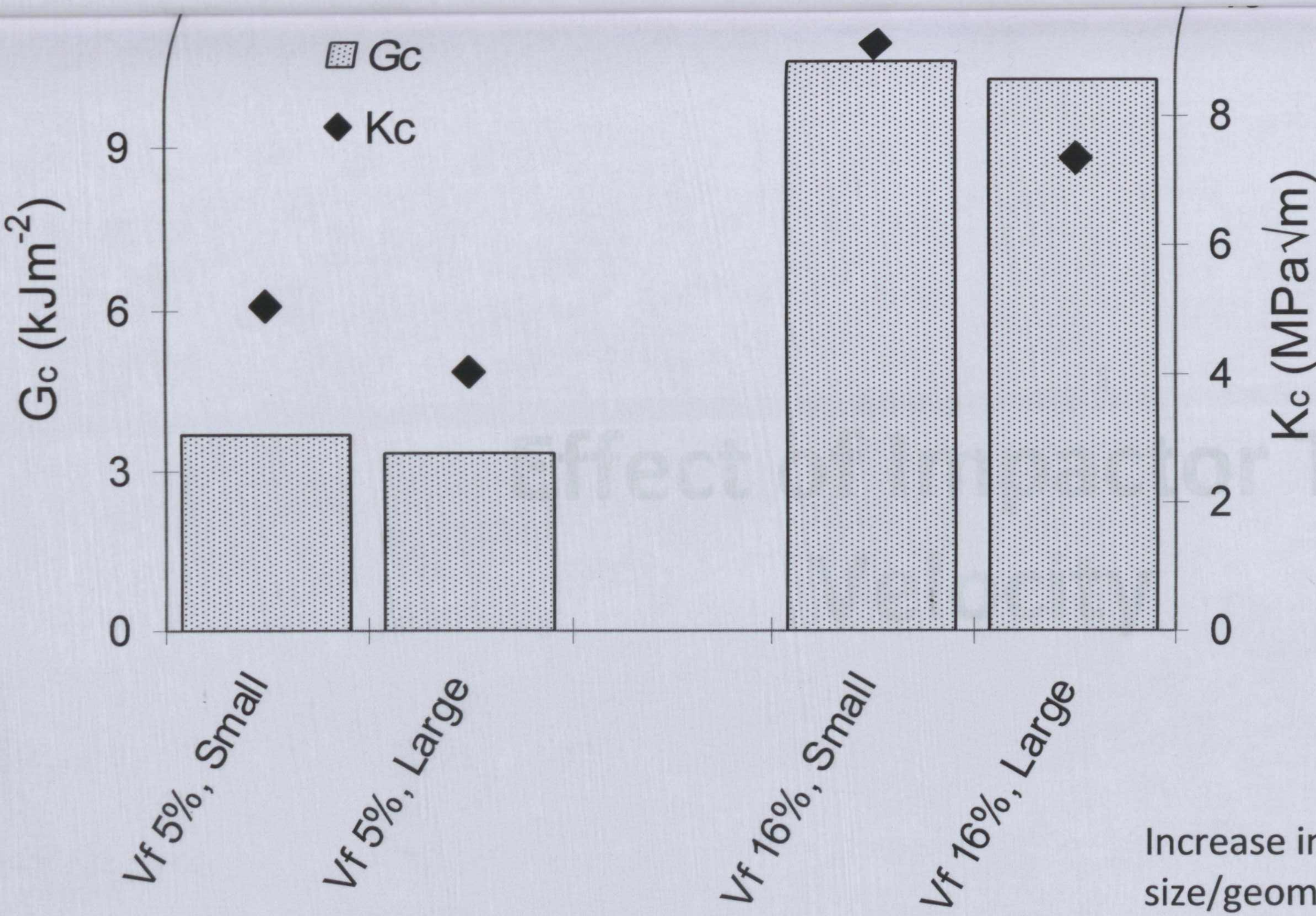
$$\sigma Y = \frac{K_c}{\sqrt{a}}$$

$$\sigma = \frac{6PS}{4BD^2}$$

$$Y = 1.93 - 3.07\left(\frac{a}{D}\right) + 14.53\left(\frac{a}{D}\right)^2 - 25.11\left(\frac{a}{D}\right)^3 + 25.80\left(\frac{a}{D}\right)^4$$



◇ Vf 5%, Small
□ Vf 5%, Large
△ Vf 16%, Small
○ Vf 16%, Large
$\sigma Y = \frac{K_c}{\sqrt{a}}$
σY (MPa)
400
300
200
100
0
0
10
20
30
$a^{-0.5}$ $(m^{-0.5})$

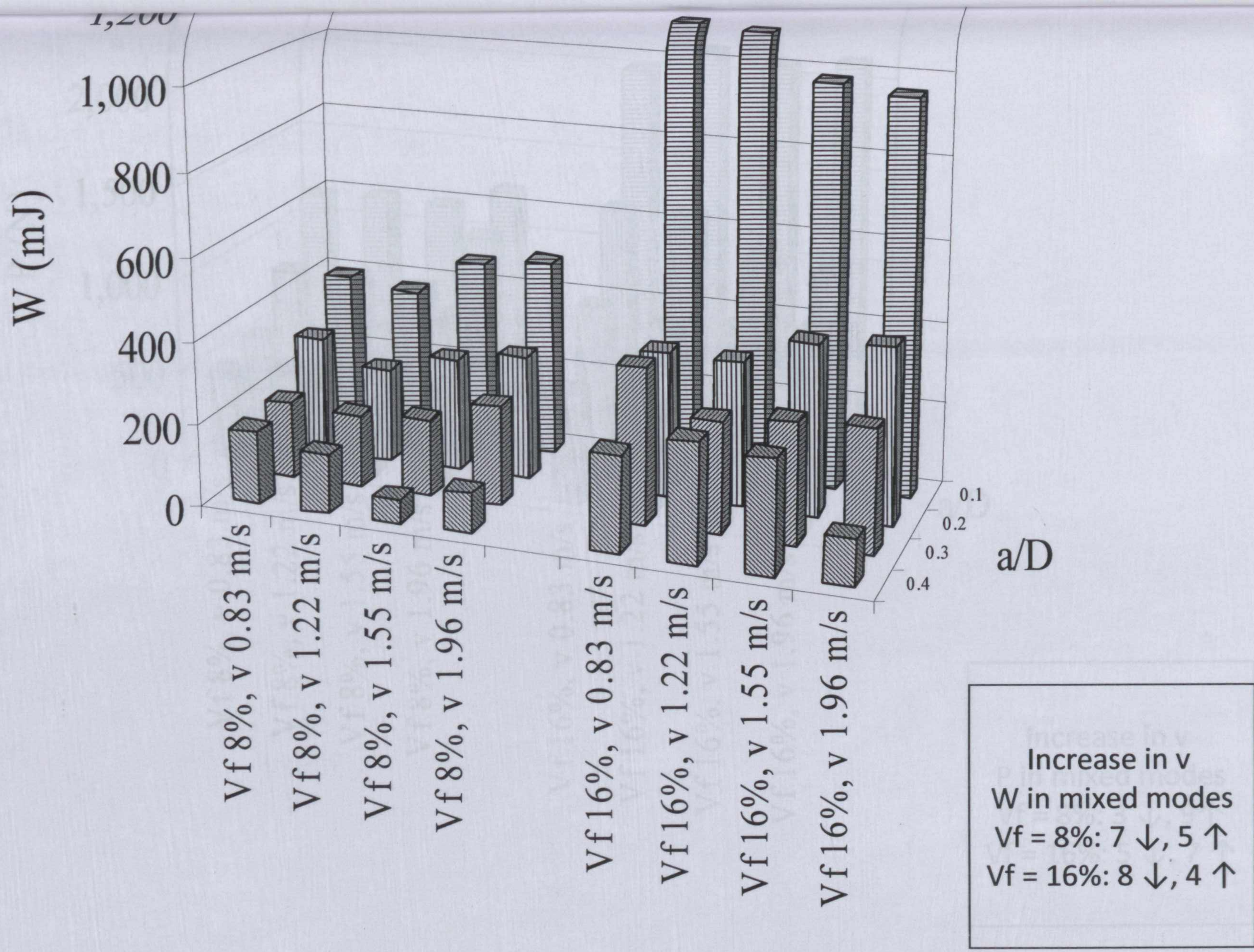


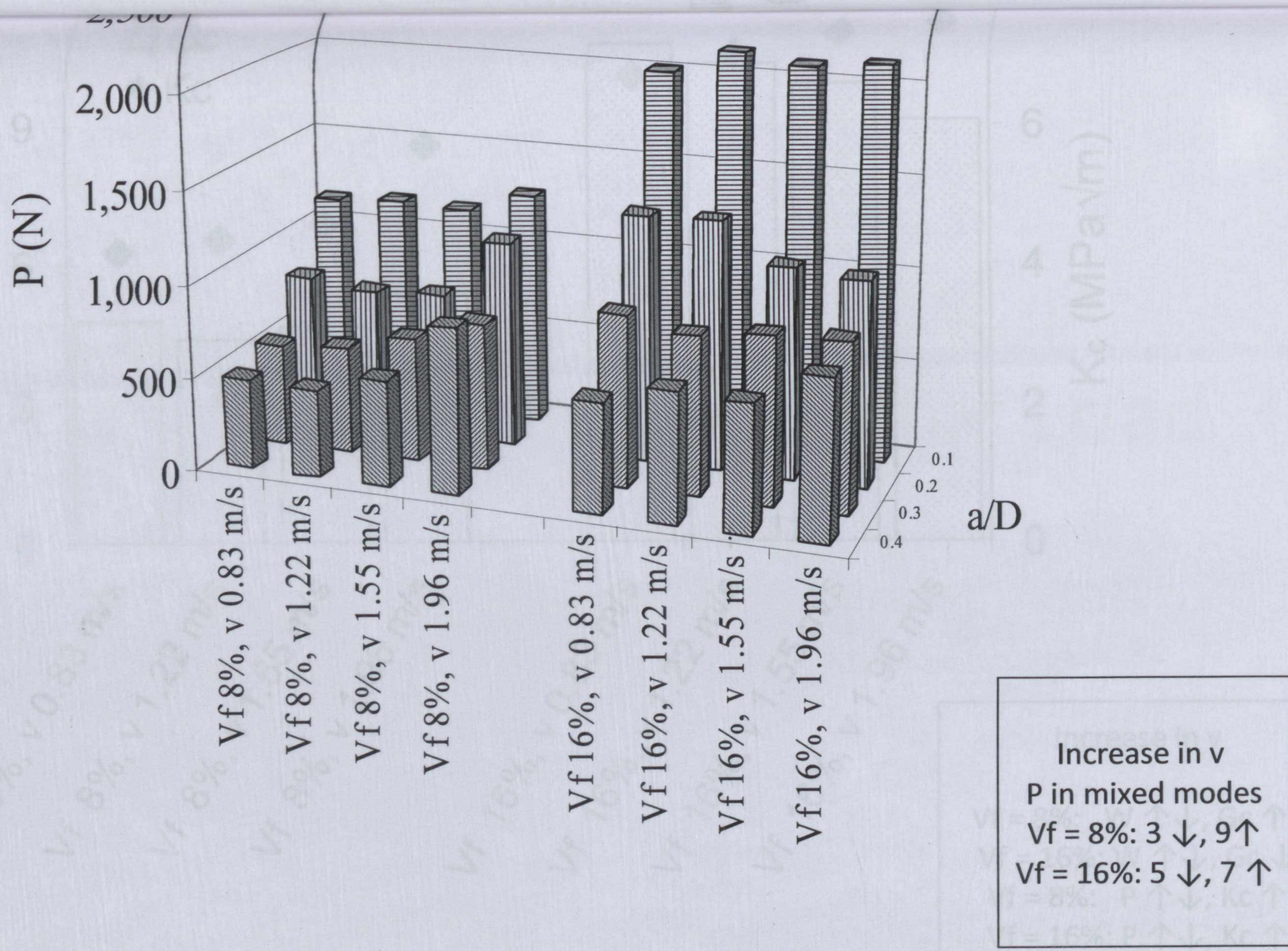
Increase in specimen size/geometry (25%)

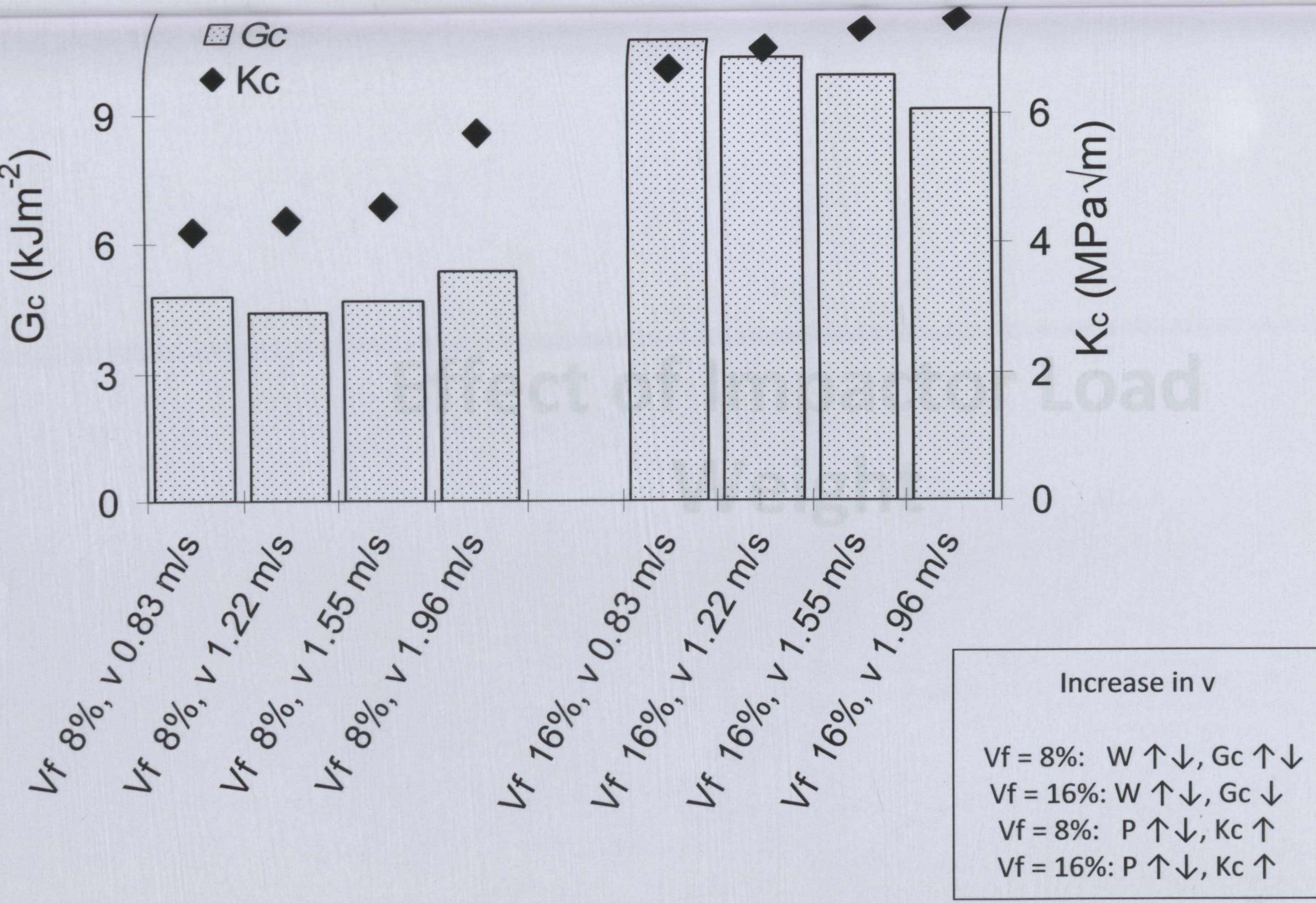
- W ↑, Gc ↓
- P ↑, Kc ↓

At both Vf

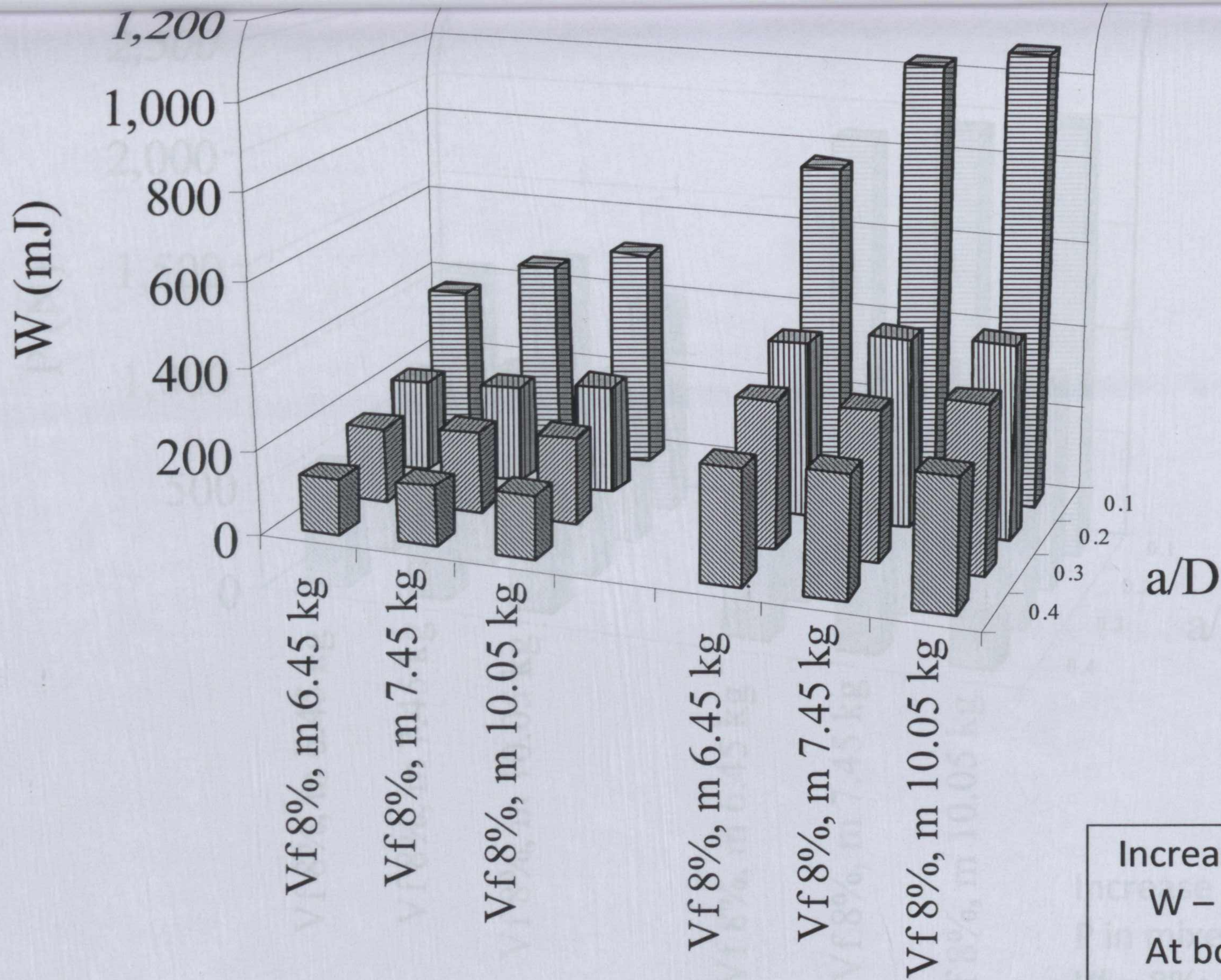
Effect of Impactor Tup Velocity


1,200
1,000
800
600
400
200
0
W (mJ)
Vf 8%, v 0.83 m/s
Vf 8%, v 1.22 m/s
Vf 8%, v 1.55 m/s
Vf 8%, v 1.96 m/s
Vf 16%, v 0.83 m/s
Vf 16%, v 1.22 m/s
Vf 16%, v 1.55 m/s
Vf 16%, v 1.96 m/s
0.1
0.2
0.3
0.4
a/D
Increase in v
W in mixed modes
Vf = 8%: 7 ↓, 5 ↑
Vf = 16%: 8 ↓, 4 ↑

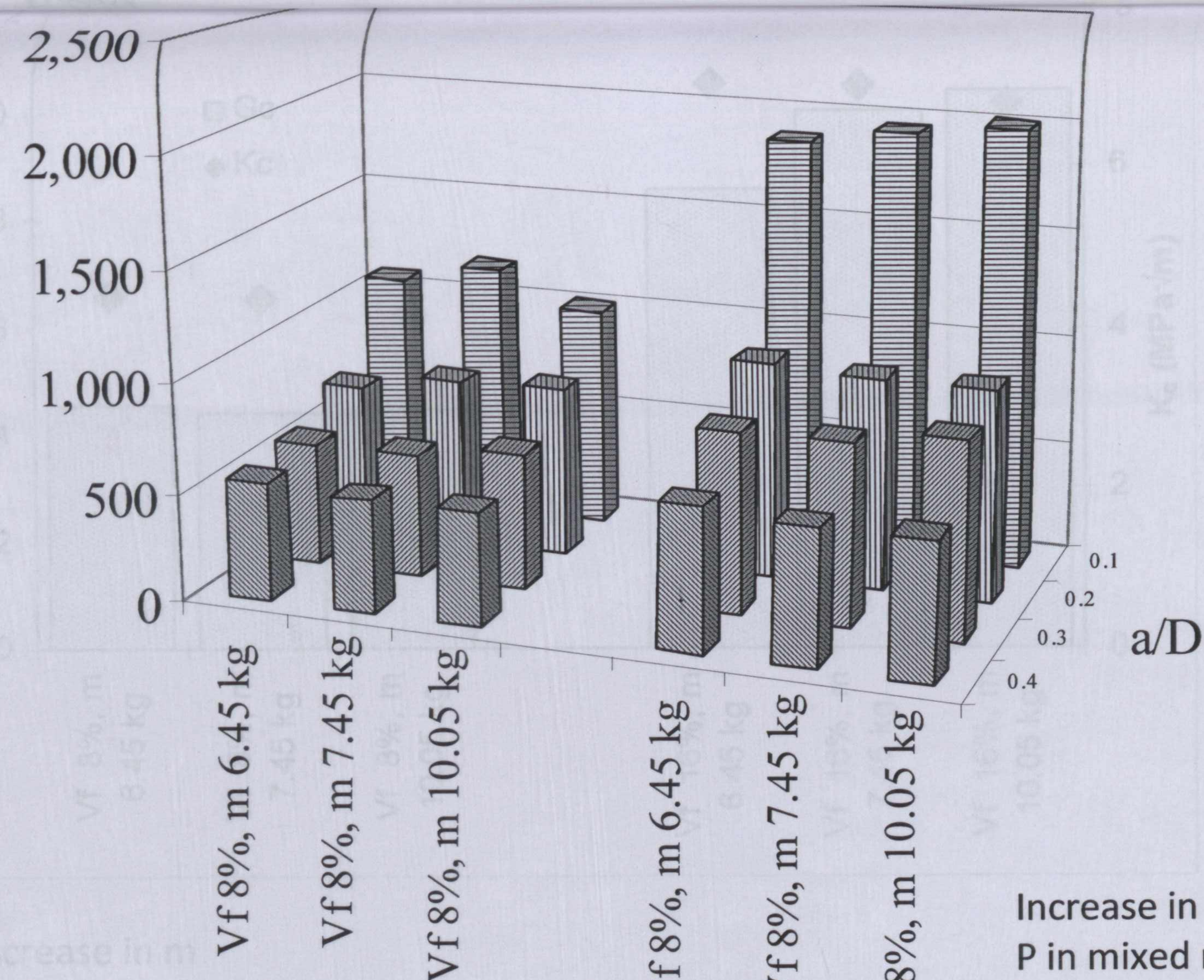

P (N)
2,000
1,500
1,000
500
0
Vf 8%, v 0.83 m/s
Vf 8%, v 1.22 m/s
Vf 8%, v 1.55 m/s
Vf 8%, v 1.96 m/s
Vf 16%, v 0.83 m/s
Vf 16%, v 1.22 m/s
Vf 16%, v 1.55 m/s
Vf 16%, v 1.96 m/s
0.1
0.2
0.3
0.4
a/D
Increase in v
P in mixed modes
Vf = 8%: 3 ↓, 9↑
Vf = 16%: 5 ↓, 7 ↑


Gc
Kc
Gc (kJm-2)
Kc (MPa√m)
9
6
3
0
6
4
2
0
Vf 8%, v 0.83 m/s
Vf 8%, v 1.22 m/s
Vf 8%, v 1.55 m/s
Vf 8%, v 1.96 m/s
Vf 16%, v 0.83 m/s
Vf 16%, v 1.22 m/s
Vf 16%, v 1.55 m/s
Vf 16%, v 1.96 m/s
Increase in v
Vf = 8%: W ↑↓, Gc ↑↓
Vf = 16%: W ↑↓, Gc ↓
Vf = 8%: P ↑↓, Kc ↑
Vf = 16%: P ↑↓, Kc ↑

Effect of Impactor Load Weight

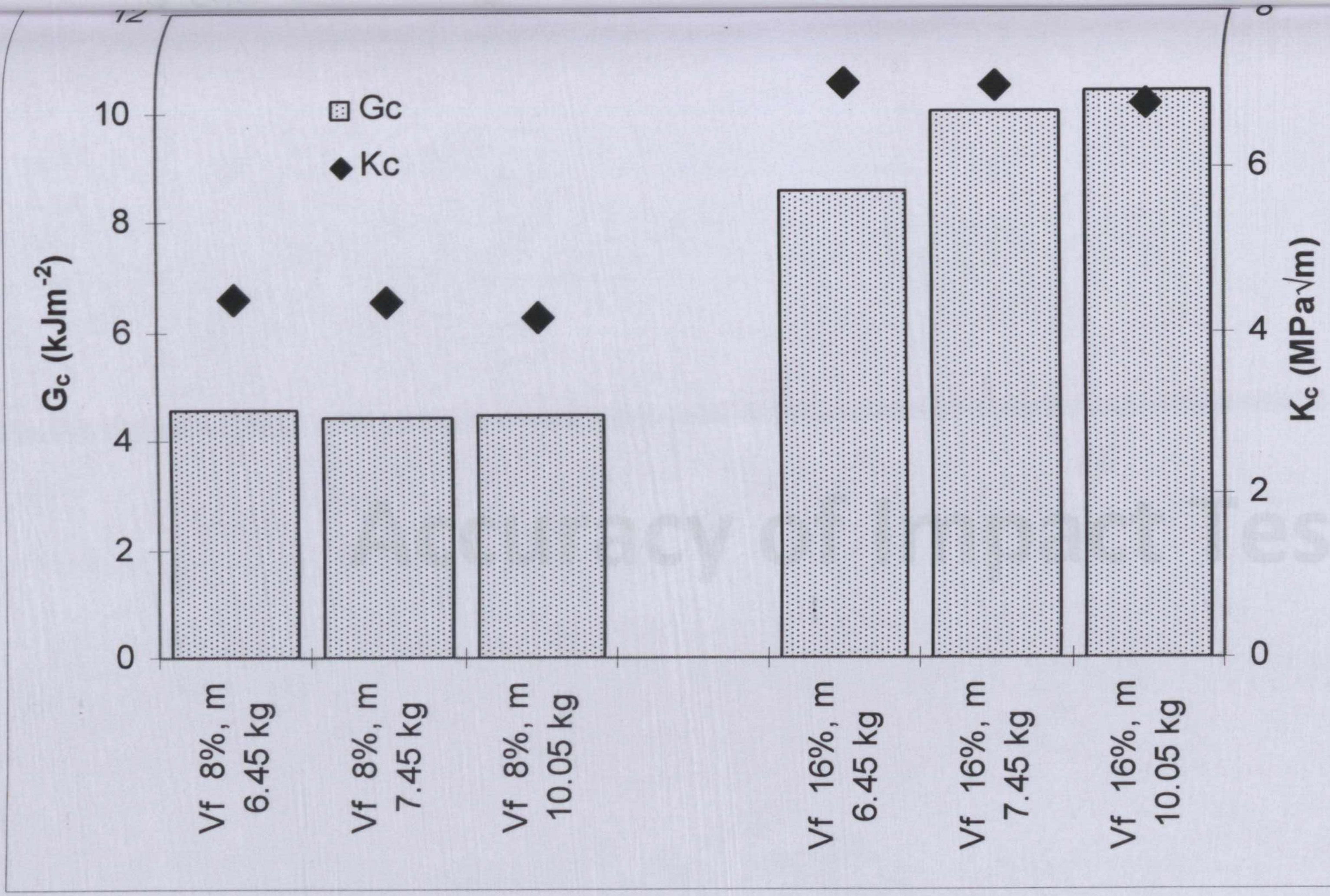


Increase in m
W – all ↑
At both V_f



Increase in m
P in mixed modes
Vf = 8%: 3 ↓, 5 ↑
Vf = 16%: 4 ↓, 4 ↑

Accuracy of Impact Test



Increase in m

Vf = 8%: W ↑, Gc ↑↓

Vf = 16%: W ↑, Gc ↑↓

Vf = 8%: P ↑↓, Kc ↓ (small)

Vf = 16%: P ↑↓, Kc ↓ (small)

Accuracy of Impact Test

$$E_{usr} = \frac{E_{use}}{E_{sup}} \times 100 (\%)$$

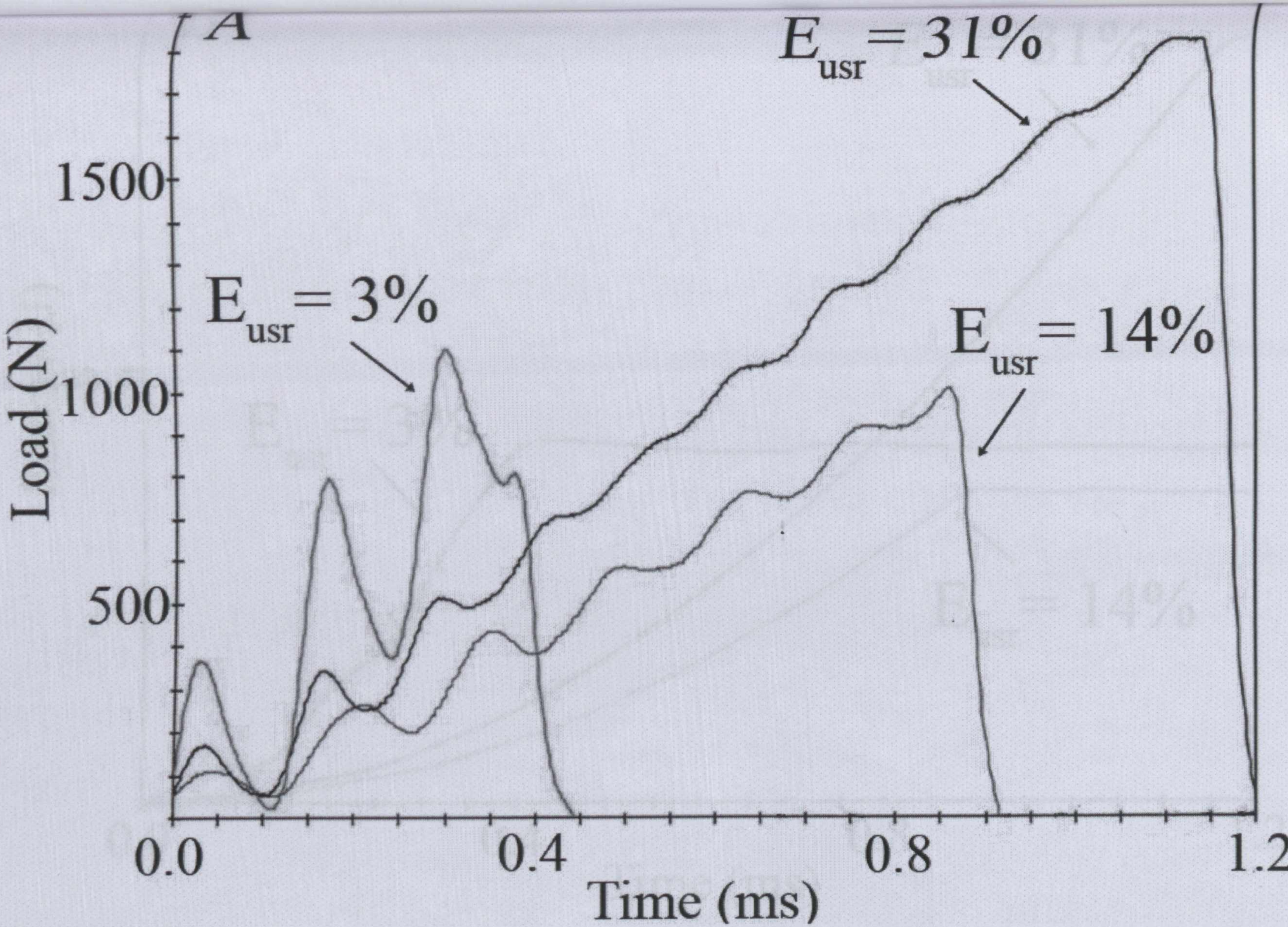
E_{use} = Energy used to break the specimen

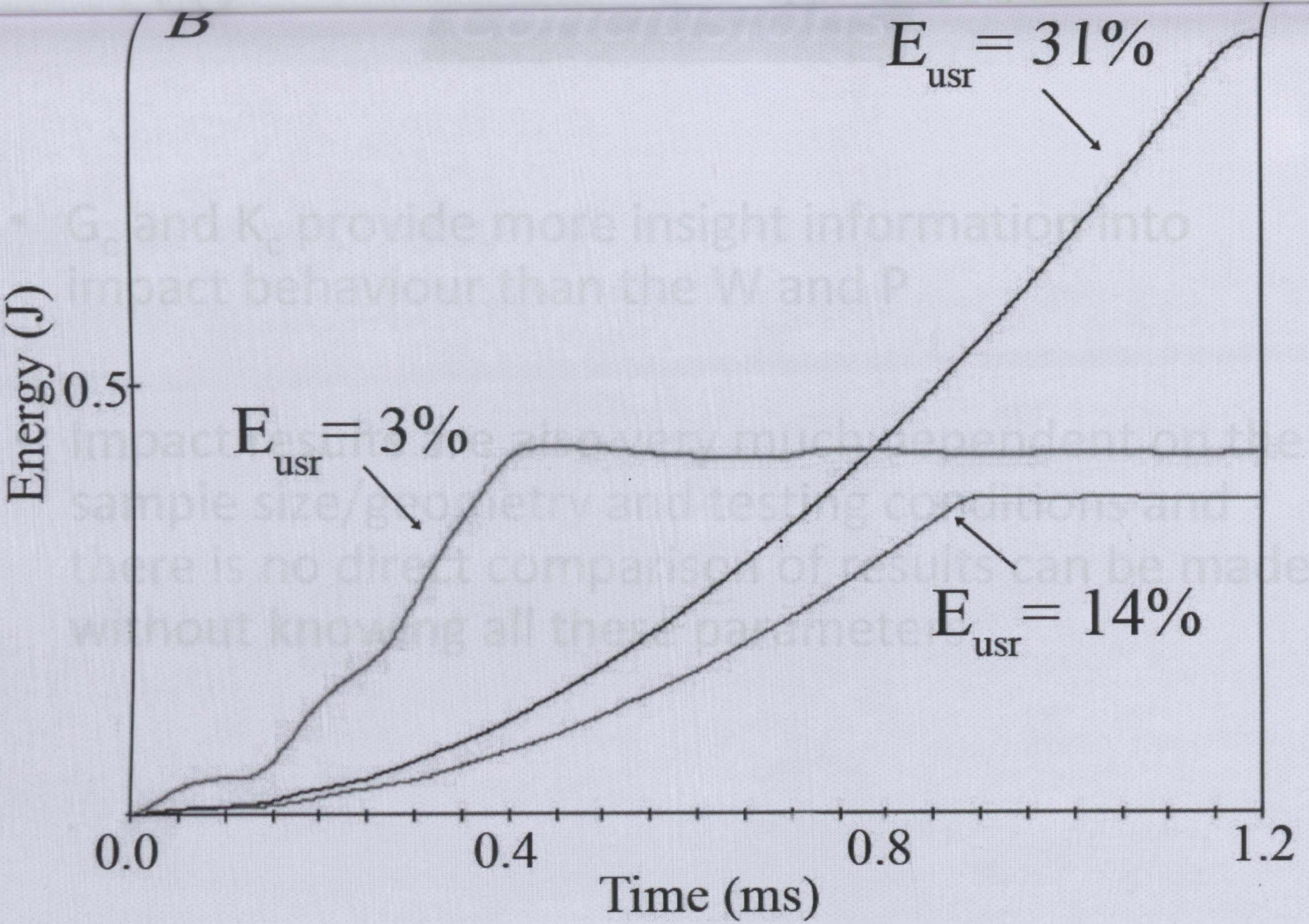
E_{sup} = Energy supplied to the specimen

$$E_{usr} = \frac{E_{use}}{E_{sup}} \times 100\,(\%)$$

E_{use} = Energy used to break the specimen

E_{sup} = Energy supplied to the specimen


A
$E_{usr} = 31\%$
$E_{usr} = 3\%$
$E_{usr} = 14\%$
Load (N)
1500
1000
500
0.0
0.4
0.8
1.2
Time (ms)



- G_c and K_c provide more insight information into impact behaviour than the W and P
- Impact results are very much dependent on the sample size/geometry and testing conditions and there is no direct comparison of results can be made without knowing all these parameters

Conclusions

- G_c and K_c provide more insight information into impact behaviour than the W and P

- Impact results are also very much dependent on the sample size/geometry and testing conditions and there is no direct comparison of results can be made without knowing all these parameters

Acknowledgements

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